332.

MEMOIRS OF THE GEOLOGICAL SURVEY.

ENGLAND AND WALES.

THE GEOLOGY OF THE COUNTRY AROUND BOGNOR.

(Explanation of Sheet 332.)

BY

Clement Reid, F.L.S., F.G.S.

PUBLISHED BY ORDER OF THE LORDS COMMISSIONERS OF HER MAJESTY'S TREASURY.

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332.

MEMOIRS OF THE GEOLOGICAL SURVEY.

ENGLAND AND WALES.

THE GEOLOGY OF THE COUNTRY AROUND BOGNOR.

(EXPLANATION OF SHEET 332.)

BY

CLEMENT REID, F.L.S., F.G.S.

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PREFACE.

THE area comprised within the Map (Sheet 332) of which the present pamphlet is explanatory, was originally surveyed by the late H. W. Bristow, and was included in Sheet 9 of the Geological Survey Map of England, published in the year 1864. In this original mapping the superficial deposits were not represented. During the general revision of the Geological Survey of the South of England, the district here described has been re-examined by Mr. Clement Reid, who in 1885 mapped it on the scale of six inches to one mile, and traced the distribution of all its superficial deposits. Two editions of the Map are issued, one showing the areas occupied by the Cretaceous and Eocene strata ("Solid Geology" edition), the other displaying the distribution of the various surface-deposits by which nearly the whole district is covered ("Drift" edition).

The present Explanation has been prepared by Mr. Reid. It is intended only as a general guide to the use of the Map, until a more detailed account of the whole surrounding region can be issued.

The tract depicted on the Map embraces that part of the Sussex coast-line which projects in Selsey Bill and includes the favourite seaside resorts of Bognor and Littlehampton. Owing to the wide spread of the various alluvia, brick-earths, and gravels, the older rocks are only seen here and there on the foreshore. But the coast includes the typical development of the "Bracklesham Beds." Another feature of interest is to be found in the occurrence of the erratic blocks on the Selsey promontory. A brief account of these and other characteristics is given in the following pages.

ARCH. GEIKIE,
Director-General.

Geological Survey Office,
28, Jermyn Street,
London, S.W.
20th August, 1897.

362. Wt. 8164. 500—11/97. Wy. & S.

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ILLUSTRATIONS.

THE GEOLOGY OF THE COUNTRY AROUND BOGNOR.

Introduction.

Sheet 332 of the Geological Survey Map takes in an area of 57 square miles in Sussex, including the coast from Selsey Bill eastward nearly to Worthing. The only towns in the district are Bognor and Littlehampton, Chichester lying a mile beyond its northern limits and Worthing about three miles to the east. For the rest, the land is fertile and flat, no part of it rising more than 30 feet above the sea-level. It is much cut up by tidal estuaries, none of which, however, with the exception of that of the Arun, is the outlet for any considerable body of fresh water.

It would not be thought on viewing this region, so devoid of salient features, that the geology could be anything but tame and monotonous. Such, however, is not the case, for we are dealing with one of those exceptional areas where physical features and underground structure are almost unconnected, and in which beneath a surface perfectly level lie strata dipping at high angles and thrown into sharp folds.

The formations represented on Sheet 332 are the following:—

Recent	Blown Sand.
	Shingle.
	Alluvium.
Pleistocene	Brickearth.
	Coombe Rock.
	Marine gravels and clays.
	Erratic beds of Selsey.
Eocene	Bracklesham Beds.
	Lower Bagshot Beds.
	London Clay.
	Reading Beds.
Cretaceous	Upper Chalk.

As the whole of the area away from the coast is covered with Drift, we are obliged to depend on information derived from well-sinkings and casual excavations for tracing the limits of the different formations. It is found on piecing together this information that two marked anticlines traverse the country from east to west. The axis of the one strikes the coast about Littlehampton, then passes westward about two miles north of Bognor, and dies out close to North Mundham. Another disturbance commences near where this one dies out; but like all the Tertiary folds in the south of England it forms an independent anticline arranged *en échelon* with the dying one, and not appearing in exactly the same line.

The deposits in the neighbourhood of Bognor of especial interest to geologists are three:—The highly-fossiliferous sandstone in the

London Clay, known as the Bognor Rock; the exceptionally fine development of fossiliferous Bracklesham Beds on the foreshore on each side of Selsey Bill; and the fossiliferous Pleistocene strata of Selsey, in which is intercalated a mass of erratic blocks transported by floating ice.

Chalk.

Though two anticlines bring Chalk to the surface immediately beneath the Drift over nearly half the area of the map, it is difficult to say to what zones this Chalk belongs, or whether zones older than the Upper Chalk may not be exposed on the foreshore towards Worthing. The well at Littlehampton Waterworks, the site of which is near the axis of the Worthing anticline, seems to penetrate nearly to the base of the Chalk, though it is not easy altogether to understand the details communicated by Mr. R. F. Grantham. The section he gives is as follows:—

		Feet.
[Drift, 19½]	Brickearth	7
	Earth and sand...	5
	Stiff clay and sand	7½
[Upper Chalk, 95½]	Chalk, dyed yellow	5½
	Pervious white chalk	17
	Hard white chalk	12
	Hard white chalk with a few flints...	5
	Hard white chalk with many flints...	27
	Solid white chalk, very hard, no flints	29
[Middle Chalk and Lower Chalk, 391]	Impervious clunch	8
	Hard white chalk	236
	Clunch...	2
	Blue chalk marl, very hard ...	6
	[undescribed]	11
	Soft chalk, light blue	35
	Solid white chalk	61
	Impervious grey chalk	32
		506

If the classification suggested in square brackets be approximately correct, we might expect to reach Chloritic Marl and Upper Greensand within a few feet, for the combined thickness of the flintless Lower and Middle Chalk in Sussex is usually about 400 feet. In the absence of specimens it is impossible, however, to identify the different zones.

The only exposures of Chalk visible at the surface are seen on the foreshore at extreme low-water east of Felpham, and on the margin of the Chichester Channel near Dell Quay. In each locality it is difficult to distinguish shattered Chalk from Coombe Rock, and to collect fossils is almost impossible.

Reading Beds.

Red-mottled clays, lignite and sand of this age reach a thickness of 100 feet, and have been proved in numerous wells; but thus far they have yielded no fossils.

London Clay.

A low cliff at Bognor shows London Clay of a somewhat sandy type, containing a bed of hard fossiliferous calcareous sandstone,

Fossils of the Bognor Rock.

Fig. 1. Voluta denudata, *Sow.* (½ natural size.)

Fig. 2. Vermetus bognoriensis, *Mant.*

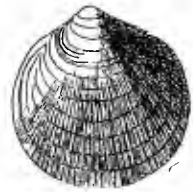


Fig. 3. Pectunculus brevirostris, *Sow.* (½ natural size.)

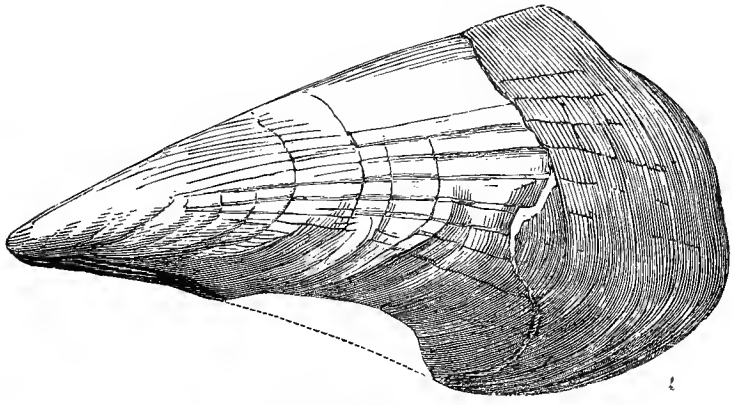


Fig. 4. Pinna affinis, *Sow.*

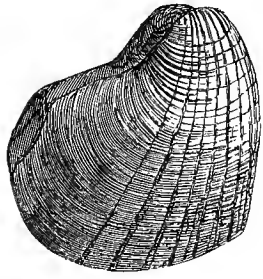


Fig. 5. Pholadomya margaritacea, *Sow.*

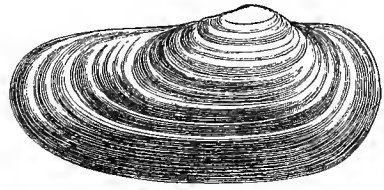


Fig. 6. Panopæa intermedia, *Sow.*

which forms a dangerous ledge running out to sea in an east-south-easterly direction. This ledge is so conspicuous that one is apt to forget that it is a mere subordinate rock-bed included in a thickness of some 300 feet of London Clay, which in so flat a district is not easy to examine. The Bognor Rocks have long been celebrated for the fossils which the sandstone contains, the shells being uncompressed, and, as one would expect, somewhat different from those in the typical London Clay. Among the more abundant may be mentioned *Voluta denudata* (Fig. 1), *Pinna affinis* (Fig. 4), *Pholadomya margaritacea* (Fig. 5), *Pectunculus brevirostris* (Fig. 3), *P. decussatus*, *Cardita Brongniarti*, and *Panopæa intermedia* (Fig. 6). The flat-coiled annelid *Vermetus bognoriensis* (Fig. 2) is also plentiful, both at Bognor and in a thin rock-bed, apparently of about the same age, which crosses Chichester Channel three-quarters of a mile north of Birdham Church. Land animals are only represented by a single mammal, freshwater species by a crocodile, plants by masses of drift-wood bored by ship-worms. The fauna points to a tropical or sub-tropical sea having extended over this area during Eocene times.

Lower Bagshot Beds.

It has been found impossible separately to map this formation in the Selsey Peninsula, yet there is little doubt that it is represented by a few feet of sand, the looseness of which has facilitated the excavation of Pagham Harbour, under which they lie. The outcrop of the deposit is entirely obscured by tidal mud or superficial brickearth.

Bracklesham Beds.

The coast on each side of Selsey Bill, to anyone visiting it at high water, will seem most uninteresting as far as the geology is concerned. It must not be forgotten, therefore, that only at low-water spring-tides can the fossiliferous deposits be examined, and that at neap-tides it is usually quite impossible either to study the geology or to collect fossils. For about a week at the new-moon and a week at full-moon the Bracklesham Beds can be examined for some two or three hours in the morning and two or three in the evening. As, however, low-water spring-tides occur at about six o'clock, it is evident that the failing light makes it useless to attempt much geology during the winter months. If the coast is examined when the tide suits, one sees laid bare some of the finest exposures of fossiliferous strata visible in England. The sea retreats a long distance, leaving a wide expanse of Bracklesham Beds between low-water and mean-tide level. No doubt beach sand often hides much of this foreshore, but some of it is always visible when the tide is sufficiently low.

It is a matter of extreme difficulty to estimate the thickness of the Eocene strata of Selsey; for though the dip is certainly southerly, no accurate measurements of the angle are obtainable, and there is only one well-boring that throws any light on the subject. As far as one can judge, a thickness of about 500 or 600 feet of Bracklesham Beds is represented in the Selsey Peninsula, the upper part of the formation being missing.

The following account of the Bracklesham Beds is largely condensed from the description by the Rev. Osmond Fisher, who had exceptional opportunities of studying the strata during a long residence in the neighbourhood.* To him and to Prestwich we owe most of our knowledge of the succession of the strata, while the very full list of fossils is mainly due to the skilful collecting of F. E. Edwards, aided by Mr. Keeping. The list is so long that it is impossible here to reproduce it. I have therefore thought it best to confine this account to the leading and characteristic fossils, and to such as throw light on the physical and climatic conditions under which the strata were deposited, leaving the student who desires to follow up the subject to do so with the aid of the monographs mentioned below.†

The Bracklesham Beds consist of numerous alternations of greenish sand, calcareous sandstone, carbonaceous laminated clays, and masses of shells. Most of the strata are fossiliferous, and, being so clearly exposed in Bracklesham Bay, that locality has given its name to the formation. The lowest part of the series crops out under Pagham Harbour, where it is so hidden by Alluvium that it is impossible properly to study it. On examining the foreshore on the west side of the Bill one can occasionally see certain carbonaceous beds which appear to represent the base of the Bracklesham Series, though they may belong to the slightly older Bagshot Sands. The sections are so difficult of interpretation, and the relation of the different Eocene deposits to each other is so obscure, that it will be advisable to point out the nature of the evidence at West Wittering, in the hope that further research may produce the fossils needed to decide the age of the various strata.

North of Court's Farm the low cliff above Chichester Channel shows weathered London Clay underlying Pleistocene brickearth; as to this determination there will probably be no dispute. Continuing southward one does not meet with another section of Eocene strata till the Coastguard Station at West Wittering is reached. Here the low cliff shows loamy sand with black flint

---

* *Quart. Journ. Geol. Soc.*, vol. xviii., p. 65 (1862); the part relating to the Selsey Peninsula is also reprinted in Dixon's "Geology of Sussex," 2nd edit., pp. 65-68 (1878).

† *Reptilia.*—"The Reptilia of the London Clay [and Bracklesham Beds]," by Owen and Bell. *Palæontographical Soc.* "Catalogue of the Fossil Reptilia ... in the British Museum," by Lydekker.

Fishes.—"Catalogue of the Fossil Fishes in the British Museum," by A. Smith Woodward.

Mollusca.—"The Eocene Mollusca," Edwards and Wood. *Pal. Soc.* R. B. Newton, "Systematic List of the Frederick E. Edwards Collection of British Oligocene and Eocene Mollusca in the British Museum (Natural History)," 8vo (1891).

Crustacea.—"The Malacostracous Crustacea," by Bell. *Pal. Soc.*

Echinoderms.—"The Tertiary Echinodermata," by Edward Forbes. *Pal. Soc.*

Corals, by Milne-Edwards and Haime, and Supp. by Duncan. *Pal. Soc.*

Eocene Flora, by Gardner and Ettingshausen. *Pal. Soc.*

Many Bracklesham species of all classes are figured or described in Dixon's "Geology of Sussex," 4to, and in Lowry's "Figures of the Characteristic British Tertiary Fossils" (Chart), 1866.

pebbles. This may be a pebble bed near the top of the London Clay—such as is found in the Isle of Wight—but it may belong to the Bagshot Sand, or even represent the pebbly base of the Bracklesham Series: the evidence is still insufficient to decide. Crossing next to the sea-coast, near the entrance to the harbour, the wide platform of clay there seen ought, one would think, to yield the needed evidence. It shows thin-bedded blackish and blue clay, apparently resting on black and green sandy loam with flint-pebbles, the sand containing also large quantities of *Teredo*-bored drift-wood. This pebble-bed I am inclined to place at, or near, the base of the Bracklesham Series, considering it to correspond with the pebble-bed so well shown on that horizon at Whitecliff Bay in the Isle of Wight. The bedded carbonaceous clays above also agree very closely at the two localities.

Following the coast to the south-east, the next exposure was met with opposite West Wittering Beacon, where I found abundance of drifted fruits of a Nipa palm in a sandy matrix. These nuts are nearly as large as a cocoanut, and the species *(Nipa Burtini)* (Fig. 11) corresponds with one found in beds of Bracklesham age in other districts. A closely allied species now living in tropical India and Malaya always flourishes in tidal estuaries, into which it sheds its nuts until they form a real hindrance to navigation. The fossil species must have occupied similar stations, for their nuts are invariably found in estuarine or marine strata, never in lacustrine deposits.

Continuing eastward along the shore one walks over blue and green loam, unfossiliferous so far as the rare and small exposures allow one to judge. Next, due south of Cakeham Manor House, dwarf specimens of *Cardita planicosta* occur in the clay, followed by carbonaceous clays and sands with lignite bored by *Teredo*, beds of oysters, and a small sharp-ribbed *Cardita*. South-south-east of East Wittering Coastguard Station is found a fine-grained sandy glauconitic rock full of lignite bored by *Teredo*. After this there is a gap of about half a mile, over which the Bracklesham Series has always been hidden by beach-sand when I examined the district.

Bracklesham Farm, where the principal fossiliferous exposures commence, lies just beyond the western margin of Sheet 332, but the rest of the strata come within our area. South of the Farm one again meets with greenish clays, broken up and mixed with flint-pebbles, like those seen at West Wittering, though on a totally different horizon. Then follow greenish sands with the large cowry *Cyprœa tuberculosa*, immediately on which rests a mass of the large *Cardita* (*Cyprina*) *planicosta* (Fig. 10) with the valves united, mixed with *C. acuticosta*. This "Cyprina or Venericardia bed" is perhaps the most conspicuous shell-bed in the Bracklesham Series. A few yards further, near to the channel that runs from Earnley, occur the "*Turritella*-beds"—clays crowded with *Turritella imbricataria* (Fig. 8). Close to this spot was found an isolated fruit of the same Nipa that occurs at West Wittering. The "*Turritella*-beds" are also to be found on the east side of the Bill opposite Park Farm.

Fossils of the Bracklesham Beds.

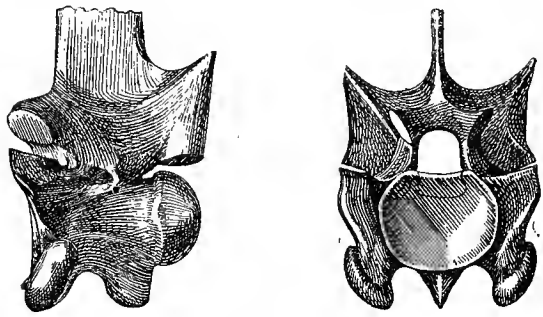


Fig. 7. Palæophis Typhæus, *Owen.*

Fig. 8. Turritella imbricataria, *Lam.*

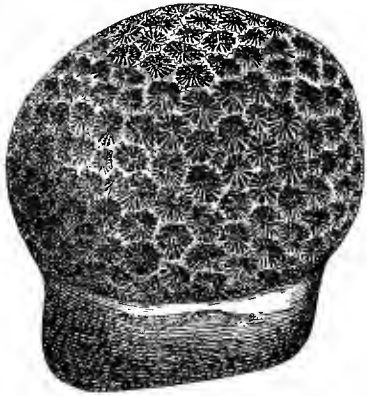


Fig. 9. Litharæa Websteri, *Bow.*

Fig. 10. Cardita planicosta, *Lam.*

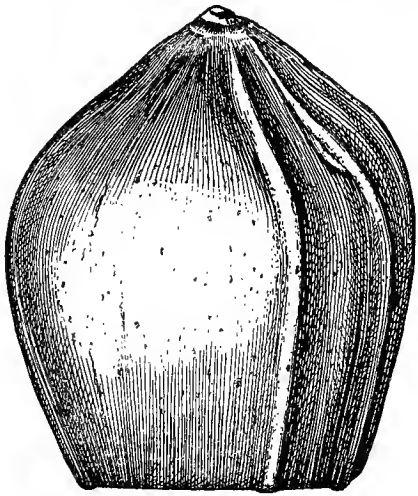


Fig. 11. Nipa Burtini, *Brongn.* (½ natural size.)

Fig. 12. Nummulites lævigatus, *Brug.* (½ natural size.)

The next conspicuous fossiliferous stratum is the "Palate-bed" of Dixon, which yields the finest remains of *Myliobates*, *Ætobates*, and *Edaphodon*, and also numerous vertebræ of the aquatic serpent *Palæophis Typhæus* (Fig. 7). Then follow loamy calcareous sands full of the coin-like *Nummulites lævigatus* (Fig. 12), also well seen at Little Park, half a mile north of Selsey Coastguard Station. This deposit is of great interest, for it is almost our sole representative of the massive Nummulitic limestones which form so conspicuous a feature in deposits of the same age in the Mediterranean region.

Still following the coast to the south-east, within a quarter of a mile of Thorney Farm occur sands with the gigantic *Cerithium giganteum*, sometimes reaching a length of two feet. These deposits can only be examined at extreme low water. Opposite the farm itself is brownish clay with *Arca duplicata*. In front of Medmerry Farm is the "Beloptera-bed" of Dixon, so called from the remains of this cuttle-fish contained in it. The deposit is also full of microscopic foraminifera. Adjoining this is the "*Cyprœa*-bed," which yields the *Cyprœa Bowerbankii* and other rare shells. Passing Thorney Coastguard Station we reach the highest Eocene deposits represented in the Selsey Peninsula. These consist of clays and sandy rock-beds full of foraminifera, such as *Nummulina varioloria*, *Alveolina sabulosa*, &c. The Mixen Rocks, opposite Selsey, yield the Alveolina-limestone, of which so much of the village is built. It is no longer quarried, as the removal led to a more rapid wasting of the coast. This limestone is probably 150 feet below the base of the Barton Clay.

The Bracklesham Beds, viewed as a whole, are noteworthy for the variability of the strata, the prolific fauna they yield, and the tropical or subtropical aspect of the species. Abundance of drift-wood and fruits of Nipa, and seams of flint-pebbles appear at first sight to point to the close proximity of the land; but this appearance is somewhat deceptive, for most of the wood floated till it became thoroughly worm-eaten, and at last sank waterlogged; nuts of Nipa drift far and wide, like cocoanuts; and the smooth polished pebbles may be beach-stones transported by floating sea-weed or trees and dropped into deep water. Unmistakable evidence of the proximity of land is almost wanting at Bracklesham; for only one land-mammal and no land-mollusca have yet been found, and the thin coal-seam and underclay occurring at White Cliff Bay have not yet been observed at Selsey. The whole of the evidence suggests the existence of an estuary, and of marine currents, which transported the drifted material to this spot. None of the mollusca, except perhaps a *Cyrena*, point to brackish-water conditions.

Among the fossils which give so tropical an aspect to the Bracklesham fauna may be mentioned remains of Crocodiles and Turtles, and of aquatic Serpents, one of which was about twenty feet in length; shells of large Volutes, Cowries, Cones, Olives, Mitres, and of the Nautilus; Corals—none of which, however, are reef-building forms, though *Litharœa Websterii* (Fig. 9) growing on flint-pebbles may often form masses of two or three pounds weight—and lastly fruits of the Nipa-palm.

Pleistocene.

The Cretaceous and Eocene strata over the whole of the area included in Sheet 332 have been planed down by the sea to a nearly uniform level before the more recent deposits now to be described were laid down. The result of this planing has been to produce a wide nearly level platform, rising very gently from Selsey Bill to Chichester, bounded on the north, outside our district, by an ancient buried and degraded sea-cliff. Whether the formation of this feature belongs entirely to one period is doubtful; but the oldest deposits now preserved upon the platform date back only to the time when the cold of the Glacial Period had reached its greatest intensity, and the English Channel was blocked by floating ice.

The Pleistocene deposits found in the area may be grouped into three series. At the bottom is an Arctic marine deposit of rough gravel with large far-transported erratics, and a few sea-shells. Next, though probably laid down after a long interval not bridged by any records yet discovered, is found a marine clay full of sea-shells belonging to a depth of 10 or 20 fathoms, and to a sea somewhat warmer than the present English Channel. Then follow shoal-water and estuarine carbonaceous muds with estuarine shells and plant-remains, upon which rests well-rolled beach shingle. This series of temperate marine strata seems to belong to an inter-glacial mild period, for upon it is deposited a sheet of unstratified angular chalky gravel or stony brickearth, which covers nearly the whole of the district, and points to a recurrence of Arctic conditions.*

The storm of 1891, by cutting back the cliff and removing the beach near Medmerry Farm, laid bare a wide foreshore of Bracklesham Beds. Slightly above mean tide level the junction

Fig. 13.—Diagram-section to show the relation of the erratic blocks to the floor of Bracklesham Beds.

of the Eocene and the Pleistocene strata was exposed, the surface of the hard Eocene clays being full of basins or pits from two to six feet across. Four out of every five of the basins contained nothing but loose gravel, but each of the others contained an erratic block, which had not merely been dropped, but showed signs of having been squeezed into the clay, until its upper surface was flush with the general level. Drift-ice grounding on the ancient foreshore dropped its burden of erratics between tide-marks. Here they were pressed deeper and deeper into the clay, for the rise and fall of the tide at high water piled ice upon any projecting rock, while at low water the rock was pressed down by the weight of the ice till it was flush with the general surface. Often, however, the still-projecting boulder would be firmly frozen into a new ice-foot, and would then be gently lifted out of the hole at the rise of the spring tides. It is thus that I would account for the occurrence of empty pits, for they seem to

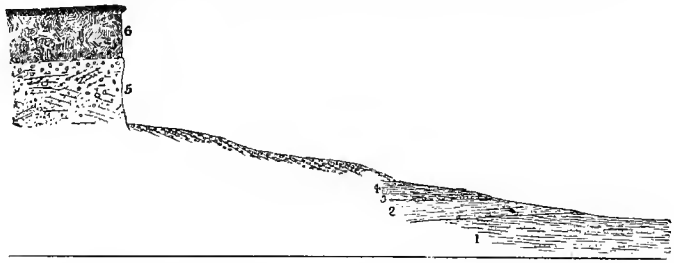
* Reid, "Pleistocene Deposits of the Sussex Coast." . . . . *Quart. Journ. Geol. Soc.*, vol. xlviii., pp. 344-361 (1892).

mark the former sites of blocks which may have shifted their position several times before finally coming to rest.

The erratic blocks found in these pits belong to various known localities, from which they could scarcely have been brought except by the agency of floating ice. We find Bembridge Limestone from the Isle of Wight; Bognor Rock from Bognor Ledge (one of the blocks showing glacial striæ); Chalk flints and Greensand, probably from the Isle of Wight; and Palæozoic sandstone, Greenstone, Granite, probably from the Channel Islands.

The next deposit shows, as already remarked, a complete change of conditions. Near low-water mark opposite Thorney Coastguard Station the Bracklesham clays are bored by *Pholas crispata*, and in the borings and also in some reconstructed clay a quarter of a mile to the south-east one finds abundance of marine mollusca, which point to a temperate sea. A few of the mollusca indeed no longer live in the English Channel, being now confined to more southern latitudes. Of these perhaps the most interesting are *Pecten polymorphus* and *Chiton siculus*, neither of which now extends north of the Bay of Biscay. The carbonaceous clays that follow still point to a genial climate, for among other fossils one meets with a south European maple, *Acer monspessulanum*. The shingle above yields no fossils. A section, seen nearly a quarter of a mile south-east of Thorney Gap, is shown in Fig. 14, but at this spot the erratic deposit is missing.

FIG. 14.—Section of the cliff and foreshore at Selsey Bill.



(Scale, vertical, 20 feet = 1 inch; horizontal, 100 feet = 1 inch.)

		FEET.
6.	Stony loam, gravelly at base, chalky where unweathered (= Coombe Rock)	6
5,	Shingle, with occasional fragments of Greensand chert and other erratics (= Raised Beach of Brighton?) ...	4
	Sand and shingle	3
	Hidden under recent beach (probably all sand and shingle as above)	6
4.	Black, stony, estuarine mud, with driftwood, acorns, *Scrobicularia* in the position of life, *Hydrobia ulvæ*, *Littorina obtusata*, *Rissoa parva*, *Utriculus*, *Tellina balthica*, *Cardium edule*	2
3.	Stony clay with numerous re-deposited erratics (base of No. 4)	0½
2.	Hard greenish clay, full of derivative Bracklesham fossils, and with Pleistocene marine mollusca. *Chiton siculus*, *Rissoa cimex*, &c. Occasional large Chalk flints and erratic blocks. (This deposit is likely to be confounded with the underlying Eocene strata, for it is mainly formed of re-deposited Bracklesham material, and contains more Eocene than Pleistocene fossils) ...	2
1.	Bracklesham Beds.	

Overlapping all the deposits already described, and hiding most of them except along the coast, comes a wide-spread sheet of rubble-gravel and loam. This has yielded few if any fossils within the area now described, though at Chichester and Brighton teeth of mammoth and horse are not uncommon in it. Remains of these animals have also been found at Selsey, but apparently belong there to the estuarine beds below, for at West Wittering they certainly come from the older stratum. This "Coombe Rock," as the gravel is locally called, and the accompanying brick-earth, appear to point to a recurrence of colder conditions, and to a period when the Chalk was rendered impervious by freezing, so that any rain falling on the frozen soil swept down the valleys carrying with it a tumultuous mass of Chalk and flint detritus.* The detritus as soon as the flatter land was reached was deposited in fan-shaped deltas extending for several miles from the mouth of the valley. The sheet covering the Selsey Peninsula, coarse and gravelly to the north, loamy to the south, seems in the main to be derived from the Lavant valley, which debouches on the plain at Chichester.

Drainage Channels.

The existing drainage system is independent of the geological structure beneath the surface. This independence arises from the exceptional way in which the whole of the rocks were planed down to one level by marine action in Pleistocene times, so that when the land again emerged there were few irregularities and nothing to direct the streams into definite channels. The almost imperceptible southern slope of the surface was enough to give a general southerly trend to the newly-forming valleys, but the anticlinal and synclinal folding in the rocks below was entirely without influence. The channels though only a few feet deep are sufficient now to prevent the drainage from taking any new course, and if the land were to rise they would continue to cut into Eocene and Cretaceous strata quite independently of either dip or strike, just as the streams that diverge from the central axis of the Weald have done. It may be observed, however, that the latest movement having been one of depression, there has been a tendency for the Selsey water-courses to silt up and become obliterated. If, therefore, the next movement were to be a depression of ten feet, instead of an elevation, it might cause the complete silting up of the channels, so that on a re-elevation an entirely fresh set would have to be cut.

Changes in the Coast.

Few parts of Sussex have suffered so great a change within the historic period as has occured in the Selsey peninsula. The seat of the bishopric was formerly in the town of Selsey, now entirely destroyed by the sea. The changes are still going on at so fast a rate as markedly to alter the coast line,

* *See* Reid, "On the Origin of Dry Chalk Valleys and of Coombe Rock." *Quart. Journ. Geol. Soc.*, vol. xliii., p. 364.

even in the short period since the six-inch Ordnance Map was made. Details of this loss of land will be found in Dixon's Sussex (2nd edit.), pp. 14-17, 73, 74.

Loss and growth of land are intimately correlated. We find therefore that the rapid destruction of the coast corresponds with the piling up of the coarser material in the mass of shingle which now entirely blocks the entrance to Pagham Harbour. Sand-dunes accumulating at the mouth of the Arun show also where another portion of the destroyed land is being deposited. The finer material is swept out to sea and lost.

Economics and Water Supply.

There is little to be said as to the economic geology of this area. Though good agricultural land, it is emphatically not a mineral district. Cement-stones and copperas (iron-pyrites) were formerly gathered on the shore in small quantities. Marl-pits were dug in the Coombe Rock or Chalk, and building-stone from the Bracklesham Beds was quarried on the foreshore off Selsey. These industries are now entirely abandoned, and a few brickyards, and sand or gravel pits alone remain.

Water-supply, however, is a matter of growing importance as the population increases. For a single house sufficient water can usually be found in the superficial deposits, though the quality is indifferent, and the risk of contamination considerable. Where Chalk lies within a reasonable distance of the surface there is usually little difficulty in obtaining good water, and both Littlehampton and Bognor are supplied from this source, as are various isolated farms. The water from the Eocene strata is usually poor in quality, and a well bored to 552 feet at Park Farm, Selsey, obtained no sufficient supply. Another boring, at Sefter School, reached Chalk at 279 feet, and then penetrated 188 feet into the Chalk without obtaining water.

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